14:06:06 OCA PAD INITIATION - PROJECT HEADER INFORMATION 01/31/92

Active

Project #: E-25-M60 Cost share #: Rev #: 0
Center # : 10/24-6-R7397-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: AGREEMENT DATED 1/13/92 Mod #: Document : AGR
Prime #: Contract entity: GTRC

Subprojects ? : N CFDA: N/A
Main project #: PE #: N/A

Project unit: MECH ENGR Unit code: 02.010.126
Project director(s):
BAIR S S III MECH ENGR (404)894-3273

Sponsor/division names: IMPERIAL OIL / ONTARIO, CANADA
Sponsor/division codes: 701 / 018

Award period: 920113 to 920412 (performance) 920412 (reports)

Sponsor amount	New this change	Total to date
Contract value	10,500.00	10,500.00
Funded	10,500.00	10,500.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: PRESSURE VISCOSITY MEASUREMENTS

PROJECT ADMINISTRATION DATA

OCA contact: E. Faith Gleason 894-4820

Sponsor technical contact	Sponsor issuing office
DR. ALAN BLAHEY	FRANK F. VAUTOUR
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P.O. BOX 3022	P.O.BOX 3022
SARNIA, ONTARIO	SARNIA, ONTARIO
CANADA N7T 7M1	CANADA N7T 7M1

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : N/A N/A supplemental sheet
Equipment title vests with: Sponsor GIT
N/A
Administrative comments -
INITIATION OF FIXED PRICE AGREEMENT WITH A FOREIGN SPONSOR.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

SR6882

Closeout Notice Date 04/01/92

Project No. E-25-M60 Center No. 10/24-6-R7397-0A0

Project Director BAIR S S III School/Lab MECH ENGR

Sponsor IMPERIAL OIL/ONTARIO, CANADA

Contract/Grant No. AGREEMENT DATED 1/13/92 Contract Entity GTRC

Prime Contract No. _____

Title PRESSURE VISCOSITY MEASUREMENTS

Effective Completion Date 920412 (Performance) 920412 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	
Final Report of Inventions and/or Subcontracts	Y	
Government Property Inventory & Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other _____	N	

Comments_____

Subproject Under Main Project No. _____

Continues Project No. _____

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other _____	N
_____	N

NOTE: Final Patent Questionnaire sent to PDPI.

PRESSURE-VISCOSITY MEASUREMENTS

final report to

Esso Petroleum Canada
a Division of Imperial Oil
P. O. Box 3022
Sarnia, Ontario
CANADA N7T 7M1

by Scott Bair
Tribology and Rheology Laboratory
George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology

March, 1992

INTRODUCTION

The Georgia Tech Tribology and Rheology Lab has undertaken the measurement of viscosity of liquid lubricant samples to high pressure for various temperatures. Four test samples were provided by Imperial Oil. The test program was described in the November 28 Fax from Allen Blahey of Esso Petroleum. A total of seven isotherms were called for at temperatures of 50, 100 and 150°C. This final report details the dynamic viscosity at various pressures from atmospheric pressure to 760 MPa or up to the sample solidification pressure. The initial pressure-viscosity coefficient and the reciprocal asymptotic isoviscous pressure are reported. In addition, parameters for a Free Volume Model have been calculated for the two samples for which sufficient data are available.

VISCOMETER

The pressure-viscosity results reported here were obtained with a falling body viscometer which applies a maximum shear stress of approximately 20 Pa. The reported viscosities may be assumed to be the limiting low shear viscosity owing to the very low shear stress. The viscosity measurement technique is discussed in Ref. [1].

RESULTS

The measured viscosities are listed in Table I. Each entry is the average of at least two falls - more at the lowest pressures. For sample B at 150°C some entries are the average of results using two different sinkers. For sample B at 50°C and 450 MPa pressure, the viscosity was observed to increase from an initial value of 4.8×10^5 in Pa·s to 3×10^7 over a period of time. This is an indication of the formation of a crystalline phase. Other measurements were

$$T_g = T_{go} + A_1 \ln (1 + A_2 p)$$

$$F = 1 - B_1 \ln (1 + B_2 p)$$

and A_1, A_2, B_1, B_2, C_1, and C_2 and T_{go} are parameters to be evaluated. The above relations may be used to find viscosity for conditions not measured for this report.

REFERENCES

[1] Bair, S., "An Experimental Verification of the Significance of the Reciprocal Asymptotic Isoviscous Pressure", ASLE Tribology Trans., accepted for publication (1992).

[2] Yasutomi, S., Bair, S., and Winer, W., "An Application of a Free Volume Model to Lubricant Rheology", Trans. ASME Journal of Tribology, 106, 2 (1984).

TABLE I. PRESSURE-VISCOSITY RESULTS

mPa·s or cp

$$\alpha_{o,T} = \frac{1}{\mu}\frac{\partial \mu}{\partial p}\Big|_{p=o} \qquad \alpha^*_T = \left[\int_o^\infty \frac{\mu\,(p=o)}{\mu\,(p)}\,dp\right]^{-1}$$

SAMPLE:	A	B			C	D		
P/GPa	**100°C**	**50°C**	**100°C**	**150°C**	**100°C**	**50°C**	**100°C**	**150°C**
0	17.41	122.8	16.31	5.17	24.7	115.9	20.5	7.02
.069	61.0	599	53.0	12.86	95.8	400	55.5	16.56
.146	205	3032	172.4	32.0	293	1185	133.4	31.5
.223	583	12,095	492	72.4	917	3550	---	62.0
.301	1548	45,680	1239	150.4	2478	9135	566	110.5
.456	10,050	solid	7480	516	15,800	47,800	---	285
.610	63,310		37,000	1758	80,200	215,000	5883	696
.765	320,000		190,000	5110	297,000	802,000	---	1518
α^*/GPa^{-1}	17.1	22.4	16.2	12.1	17.9	16.5	12.5	10.0
α_o/GPa^{-1}	20.4	23.7	19.6	13.5	20.0	20.0	12.8	11.8

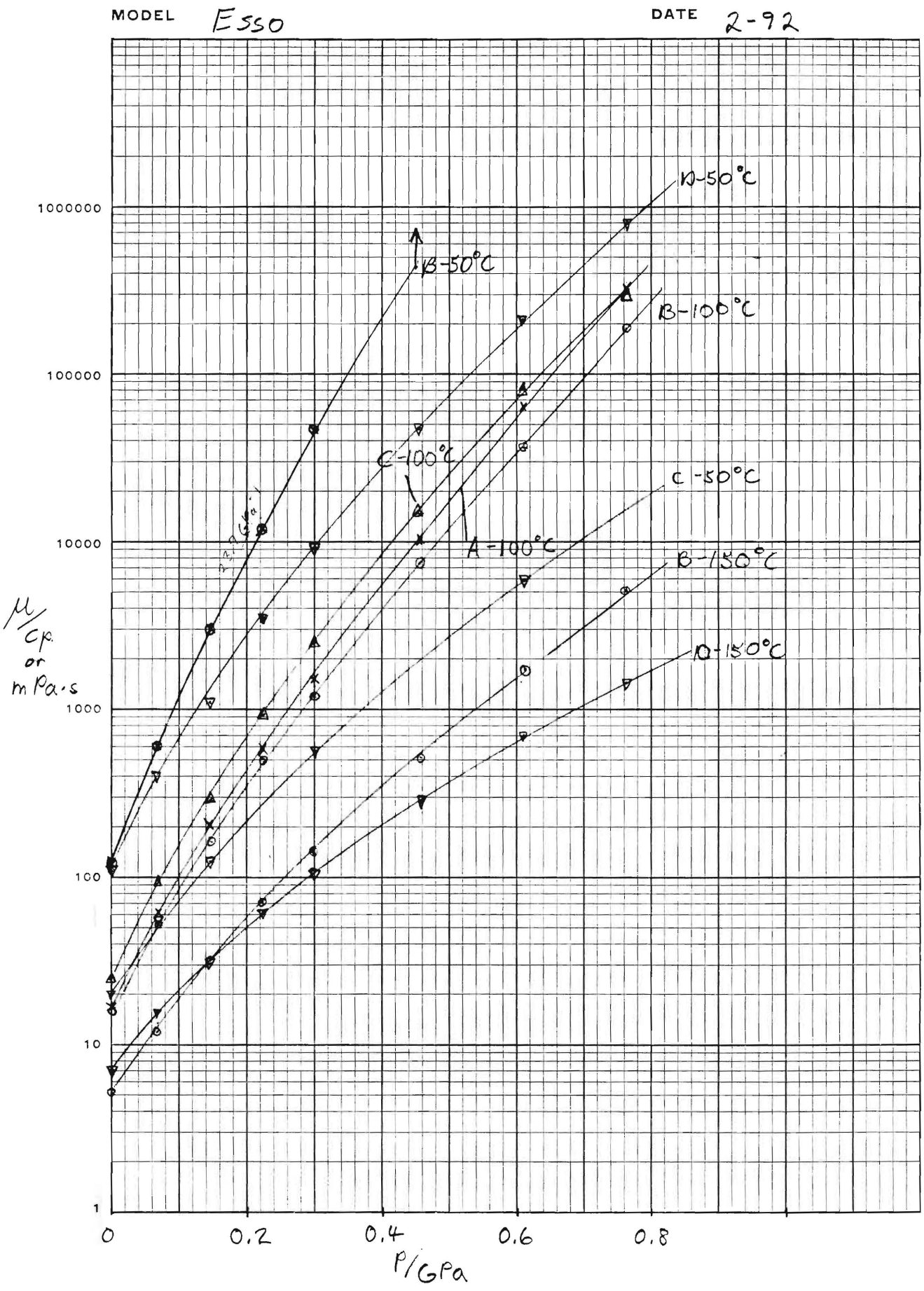
TABLE II. FREE VOLUME PARAMETERS

SAMPLE	μ_g/Pa· s	T_{go}/° C	A_1/°C	A_2 / GPa^{-1}	B_1	B_2 / GPa^{-1}	C_1	C_2/°C
B	10^7	-45.5	133.9	1.004	0.1991	24.76	11.077	37.46
D	10^7	-62.8	95.96	1.066	0.1834	26.39	10.948	41.35

where

$$\mu = \mu_g \cdot \exp\left(\frac{-2.3\, C_1\, (T-T_g)\, F}{C_2 + (T-T_g)\, F}\right)$$

$$T_g = T_{go} + A_1 \ln (1 + A_2 p)$$
$$F = 1 - B_1 \ln (1 + B_2 p)$$


MODEL Esso
DATE 2-92
D-50°C
B-50°C
B-100°C
C-100°C
C-50°C
A-100°C
B-150°C
D-150°C
1000000
100000
10000
1000
100
10
1
μ/cp or mPa·s
0
0.2
0.4
0.6
0.8
P/GPa
KEUFFEL & ESSER CO.
MADE IN U.S.A.